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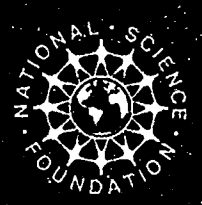
ABSTRACT

This document is a product of the workshop convened by the National Science Foundation Engineering Directorate. The 43 participants representing industry, government, education, private foundations, professional societies, and the Engineering Deans Council were charged to accept as given the consensus reflected in the reports of the past ten years on the desired characteristics of 21st Century engineering education, recommend steps to achieve these characteristics, and identify the change agents responsible for each step. Key consensus recommendations resulting from three days of deliberation are listed in this document. Appendices include a description of the workshop process, a list of recommendations, 3 one-page background papers, the workshop schedule, and a list of participants. (JRH)

SYSTEMIC ENGINEERING EDUCATION REFORM: AN ACTION AGENDA

Recommendations of a Workshop Convened by the NSF Engineering Directorate



Renaissance Hotel
Arlington, Virginia
July 11-13, 1995

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SYSTEMIC ENGINEERING EDUCATION REFORM: AN ACTION AGENDA

Recommendations of a Workshop Convened by the NSF Engineering Directorate

Renaissance Hotel
Arlington, Virginia
July 11-13, 1995

Irene C. Peden
Edward W. Ernst
Workshop Co-Chairs

John W. Prados
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In Memoriam

Workshop participants were saddened to learn that F. Karl Willenbrock, a respected leader in the engineering profession and keynote speaker at the Workshop, died on August 24, 1995. Karl's professional contributions included service as Provost at the State University of New York-Buffalo; Director of the Institute for Applied Technology of the National Bureau of Standards; Dean of Engineering at Southern Methodist University; Executive Director of the American Society for Engineering Education; Senior Scientist for the Technology Administration of the Commerce Department; and Assistant Director for Scientific, Technological, and International Affairs of the National Science Foundation. In 1989 he organized and chaired the NSF-sponsored task force that produced the report, *Imperatives in Undergraduate Engineering Education: Issues and Actions*, known as the "Belmont Report." The task force recommendations became the basis for a major NSF investment in systemic reform of undergraduate engineering education through establishment of the Engineering Education Coalitions. Those of us who labor for engineering education reform will miss Karl's leadership, his wisdom, and his friendship.

Table of Contents

Introduction

Today's engineering students will spend most of their careers in the 21st Century, coping with challenges and opportunities vastly different from those most currently-practicing engineers have faced in their professional lives. The shift from defense to commercial competition as a major driver for engineering employment; opportunities offered by intelligent technology to be more creative and "work smarter;" an expanding social infrastructure that demands a talent for complexity; an eclectic, constantly-changing work environment calling for astute interpersonal skills; and massively integrated populations placing environment, health, and safety at the front end of design will require engineers whose intellectual skills include, but extend well beyond, the traditional science-focused preparation that has characterized engineering education since World War II. Progressive industry leaders and far-sighted educators urge refocusing engineering education to emphasize the intellectual skills needed by the practicing engineer of the 21st Century.

Multiple reports over the past ten years, listed in Appendix A, show remarkable consistency in the attributes they recommend for the new breed of engineering graduates. They also agree that systemic change in engineering education will require a concurrent change from the predominant engineering school academic culture based on compartmentalization of knowledge, individual specialization, and a research-based reward structure to one that values integration as well as specialization, teamwork as well as individual achievement, and educational research and innovation as well as research in the engineering sciences. To enable such a culture change is undoubtedly the greatest challenge facing engineering education reform.

As a catalyst for future action, the NSF Engineering Directorate convened a workshop in July 1995 with the theme, *Systemic Engineering Education Reform: An Action Agenda*. The 43 participants representing industry, government, education, private foundations, professional societies, the Engineering Deans Council, and ABET were charged to accept as given the consensus reflected in the reports of the past ten years on the desired characteristics of 21st Century engineering education; to recommend steps to achieve these characteristics; and to identify the change agents responsible for each step. They were urged to keep in mind three questions: What? How? Who?

Key consensus recommendations resulting from three days of deliberation are listed in the following section. A description of the workshop process and a "long list" of recommendations appear in Appendix B. The participants received three one-page background papers; these appear in Appendix C, the workshop schedule in Appendix D, and a list of participants in Appendix E.

Key Recommendations

The Action Agenda

In summary, the workshop participants recommended:

1. That a broad segment of faculty be involved in the discussion and implementation of this action agenda for systemic engineering education reform. This involvement should be stimulated and led by engineering deans, but other approaches should be explored for motivating and realizing faculty participation.

2. That NSF encourage proposals for programs in which faculty and institutions adopt, adapt, and institutionalize successful educational innovations, including transition to full institutional support by the end of the funding period.

3. That NSF fund collaborative development and use of a nationwide infrastructure, including equipment, that enables inter-institutional communication and sharing of resources related to emerging information technologies, along with software and multimedia tools for curriculum innovation, evaluation, and implementation.

4. That NSF facilitate partnerships among engineering schools, among employers of engineering graduates, and among members of both groups, structured to offer incentives to each of the parties involved, that will: (a) form relationships to support the new paradigm for undergraduate engineering education, (b) provide transfer of knowledge among the participants; and (c) target lifelong learning and graduate engineering education.

5. That, in identifying opportunities for investment in engineering education reform, NSF, the Coalitions, and individual universities place significant emphasis on development and deployment of technologies and methodologies that enable individuals to "work smarter," i.e., to augment their ability to learn and create, both as students and as practicing engineers.

6. That NSF fund programs to enhance the academic stature of participation in systemic engineering education reform and change the faculty culture so that educational research and teaching are valued as scholarly activities and incorporated into the faculty reward system.

7. That NSF establish a committed steering group who will stay with the vision and process to stimulate implementation and institutionalization of systemic engineering education reform.

Next Steps

Successful implementation of this Action Agenda requires the active partnership of multiple institutions and groups. Next steps and the responsible entities include:

- **NSF Staff:** formulate programs to support the Action Agenda, including reallocation of funding as necessary.
- **The Engineering Deans Council and Individual Deans:** be strong, vocal advocates for the Action Agenda, enlisting the support of faculty leaders, key employers, and external visiting committees, and use resources at their disposal to encourage active participation in engineering education reform.
- **ABET:** continue its reform of engineering accreditation criteria and processes to encourage, and not inhibit, educational innovation.
- **NSF and Engineering Deans' Leadership:** identify and work with engineering employer groups to develop and refine industry-education partnerships to support the Action Agenda.
- **NSF:** establish the steering group identified in Recommendation 7 above.

Acknowledgment

We acknowledge with special thanks the inspiration, leadership, and support provided by Dr. Joseph Bordogna, NSF Assistant Director for Engineering. Warm thanks are also offered to Dr. Bordogna's staff, who handled all workshop arrangements cheerfully and effectively: Ms. Maxine Byrd, Secretary to the Assistant Director, Ms. Gloria Godwin, Administrative Clerk, and Ms. Deborah Young, Administrative Officer for the Engineering Directorate.

A large measure of the workshop's success resulted from outstanding efforts of the individual team leaders and recorders. Special thanks are due to Dr. Gretchen Kalonji, Dr. Don Kirk, Dr. George Peterson, and Dr. Tim Trick, who served as team leaders, and to the recorders, Dr. Alice Agogino, Dr. Kishan Baheti, Dr. John Hurt, and Dr. Marshall Lih.

Appendix A:

Selected Engineering Education Publications, 1985–1995

1. "Engineering Education and Practice in the United States," National Academy Press, 1985.
2. "Undergraduate Science, Mathematics, and Engineering Education," National Science Board, NSB 86-100, 1986.
3. "Quality of Engineering Education," Final Report of the Quality of Engineering Education Project, American Society for Engineering Education, September 1986.
4. "Engineering Education Answers the Challenges of the Future," Proceedings of the National Congress on Engineering Education, Accreditation Board for Engineering and Technology, Inc., November 1986.
5. "A National Action Agenda for Engineering Education," Report of an ASEE Task Force (E. E. David, Jr., Chair), American Society for Engineering Education, 1987.
6. "Workshop on Engineering - April 1988," Report of the NSF Disciplinary Workshops on Undergraduate Education, pp 51-55, NSF 89-3, National Science Foundation, 1989.
7. Karl Willenbrock *et al.*, "Imperatives in Undergraduate Engineering Education: Issues and Actions," Report of an NSF *Ad Hoc* Task Force, August 1989 ("the Belmont Conference").
8. "Education and Continuing Development of the Civil Engineer," Proceedings of an ASCE National Forum, 17-20 April 1990, American Society for Civil Engineers, 1990.
9. Roland V. Schmidt, Letter Report to E. W. Ernst of an NSF-Sponsored NAE Workshop on "Engineering, Engineers, and Engineering Education in the 21st Century," 9 May 1990.
10. "An Engineering Look Forward New Decade, New Century, New Millennium," Proceedings of the 1990 ABET Annual Meeting, 17-18 October 1990, Accreditation Board for Engineering and Technology, Inc.
11. "America's Academic Future," Report of the Presidential Young Investigator Colloquium on U.S. Engineering, Mathematics, and Science Education for the Year 2010 and Beyond, NSF 91-150, National Science Foundation, 1992.
12. "Engineering Education Issues: Report on Survey of Opinions by Engineering Deans and Employers of Engineering Graduates on First Professional Degree," NSPE Professional Engineers in Education Sustaining University Program, NSPE Publication 3059, National Society of Professional Engineers, November 1992.
13. Joseph Bordogna, Eli Fromm, and Edward Ernst, "Engineering Education: Innovation Through Integration," Journal of Engineering Education, Vol 82, No. 1, pp 3-8 (1993)
14. J. Harris, Eugene M. DeLoatch, William R. Grogan, Irene C. Peden, and John R. Whinnery, "Journal of Engineering Education Round Table: Reflections on the Grinter Report," Journal of Engineering Education, Vol 83, No. 1, pp 69-94 (1994) (includes as an Appendix the Grinter Report, issued in September, 1955).
15. "Engineering Education for a Changing World," Report of a Joint Project of the ASEE Engineering Deans Council and Corporate Roundtable, American Society for Engineering Education, 1994.
16. "Industry 2000: Technical Vitality Through Continuing Education," Report of a workshop conducted by the IEEE Educational Activities Board in May 1994, Institute of Electrical and Electronics Engineers, Inc., 1995.
17. "Restructuring Engineering Education. A Focus on Change," Report of an NSF Workshop, NSF 95-65, National Science Foundation, 1995.
18. "Engineering Education: Designing an Adaptive System," Report of the NRC Board on Engineering Education, National Research Council, 1995.
19. John H. McMasters and James D. Lang, "Enhancing Engineering and Manufacturing Education: Industry Needs, Industry Roles," presented at the 1995 ASEE Annual Conference and Exposition, June 25-28 1995, American Society for Engineering Education.

Appendix B:

Workshop Process and Aggregate Recommendations

Workshop Process

The workshop participants met in plenary session for the first afternoon (July 11) and heard presentations that outlined the background and rationale for current engineering education reform initiatives. These presentations also emphasized the high degree of consensus among a broad range of stakeholders about the attributes needed by engineering graduates for effective participation in the 21st Century work force and the needed changes in the educational paradigm that will allow students to develop these attributes.

On the morning of the second day (July 12) participants were divided into four small groups, each charged to define an action agenda to implement the new paradigm in a timely manner, and to identify the change agents responsible for each action. At the start of the afternoon, participants were redivided among four new small groups, provided with all recommendations from the morning small group meetings, and asked to combine and refine these to produce a revised action agenda by the end of the day. That evening, the workshop and small group leaders discussed the recommendations and prepared a combined set for discussion by all participants on the following morning (July 13). The final plenary discussion produced recommendations about both *WHAT* should be accomplished by an action plan as well as *HOW* these results can be realized. The major part of the recommendations focused on *WHAT* NSF should do, either as direct action or as a stimulus for others, with anticipated responses from academe, industry, and the engineering professional societies.

Aggregate Workshop Recommendations

Recommendations for *WHAT* the Action Plan should seek to accomplish include a vision and goals for NSF and others, including engineering deans and faculties, professional societies, the National Academy of Engineering, industry, and private foundations.

I. NSF

A. NSF is strongly encouraged to continue to support the integration of education and research as enunciated in the four core strategies of its Strategic Plan.*
   1. *Develop intellectual capital.*
   2. *Strengthen the physical infrastructure.*
   3. *Integrate research and education.*
   4. *Promote partnerships.*

B. NSF needs collaboration across the Engineering, Mathematics and Physical Sciences, Education and Human Resources, and Computer and Information Sciences Directorates to support science, mathematics, engineering, and technology curriculum renewal.

C. NSF needs mechanisms whereby the structure and management of NSF programs are evaluated by their participants to enhance program effectiveness.

D. There must be consistency and continuity in Engineering Directorate leadership, vision, and implementation, particularly for matters related to education.

E. Fundamental structural changes are needed in the Engineering Education Coalitions program to enable existing Coalitions to serve as models for partnerships among engineering schools as well as to become more effective platforms for cultural change nationally. This will require a collaboration and a possible restructured cooperative relationship between the Coalitions leadership and the NSF. Fundamental changes may include:
   1. Expect new entities or alternative structures, and realignment of Coalitions, as possible outcomes.
   2. Build life cycle and transition strategies into the strategic plan of each Coalition.
   3. Develop consistent metrics for evaluation, including those that document the

*NSF in a Changing World: The National Science Foundation's Strategic Plan, Publication NSF 91-183, approved by the National Science Board, October 11, 1991, p. 3.

retention to graduation of underrepresented groups.

F. Objectives for new NSF programs include:
   1. Systemic, substantial, holistic curriculum reform:
      a) interdisciplinary, vertically integrated real design projects,
      b) approaches to enable students to learn how to "work smarter;"
      c) collaborations with colleges of arts and sciences, business, and medicine in curriculum development;
      d) couplings between engineering technology and engineering programs that emphasize complementary and evolving roles in the workplace.
   2. Bold experiments in the educational enterprise, including radically different academic organizational structures and programs for professional master's degrees.
   3. Development of metrics and assessment models for educational research and for teaching that will enhance the academic stature of these activities and:
      a) change the faculty/academic culture and faculty reward system;
      b) recognize educational research and teaching as valuable scholarly activities

G. Facilitate new/improved industry/university partnerships and government laboratory/university partnerships to:
   1. Identify and produce case studies of successful collaborations.
   2. Form relationships that support the new paradigm for undergraduate engineering education.
   3. Provide two-way transfer of knowledge between universities, industry, and government laboratories
   4. Target lifelong learning and graduate engineering education

H. Stimulate organizational structures and pedagogical models to permit students to take responsibility for their education.

I. Encourage establishment of a database of information about curricular, pedagogical, organizational, and cultural reform in engineering education

J. Establish a steering group of "true believers" who will stay with the vision and process to stimulate systemic engineering education reform

II. Others

A. Engineering deans exercise leadership to engage a broad segment of faculty in the implementation of this Action Agenda for systemic reform.

B. Engineering faculties and deans re-emphasize quality teaching skills and interest as essential criteria for new faculty appointments.

C. Engineering faculties and deans structure engineering schools to be agile to meet changing technologies and societal needs.

D. Professional Societies and NAE provide more recognition of substantive contributions to engineering education in terms of awards, professional society fellowships, and NAE memberships.

E. Determine appropriate mechanisms for industry and private foundations to support the action plan for systemic reform.

Recommendations for HOW this vision and these goals can be realized include tasks both for NSF and other groups.

III. NSF

A. Clear statements from NSF that:
   1. Each research proposal must include a plan illustrating how it will contribute to the overriding educational mission of the university.
   2. Each education proposal must incorporate a plan for implementation and institutionalization, including a commitment by the university administration to continue successful programs after NSF funding ends

B. Proposals to NSF for educational research:
   1. Must include a scholarly, rigorous approach to research in education
   2. Must include clear plans for evaluation and self-assessment
   3. Must include meaningful industrial linkages where appropriate. All proposals should include a statement that industry involvement has been considered, is/is not judged appropriate, and justification for the decision

4. Should be reviewed by panels that include specialists in educational innovation and formative educational assessment.
5. May include the following formats spanning a breadth of potential collaborations, for example:
   a) individual grants,
   b) team/cross-disciplinary grants;
   c) Coalitions/centers:
   d) partnerships with industry, colleges of education, etc.

C. Possible restructuring of the Engineering Education Coalitions could include:
1. Changes in the membership of the Coalitions.
2. Supplemental funds for cross-coalition targets of opportunity.
3. Supplemental funds for non-coalition schools to implement and refine Coalition successes.
4. Plans to transition meritorious Coalition programs with potential nationwide impact to the broader engineering community.

D. Grant Opportunities for Academic Liaison With Industry (GOALI):
1. Carefully assess how well this program is working.
2. Publicize the program in the industrial sector to encourage further industry/academic collaboration.

E. New Programs for NSF Funding:
1. Connecting the workshop group to the implementation of the Action Agenda.
2. Comprehensive, systemic restructuring of all undergraduate engineering curricula, along with the supporting organization and technologies, at a single institution (possibly funded jointly by several agencies).
3. Projects to explore distributed, collaborative resource development for shared information/communication infrastructure and use (this includes access to equipment related to emerging competitive technologies, along with software and multimedia tools for collaborative curriculum development, evaluation, and implementation).
4. Transfer of successful educational programs to other institutions and transfer of people between universities via visits, workshops, etc.
5. Collaborations between colleges of engineering and education for development of effective teaching and learning strategies for undergraduate education and for curriculum development for pre-college teachers.
6. Grants for:
   a) early faculty-teacher mentorships;
   b) engineering workshops for pre-college guidance counselors and science/math teachers;
   c) propagation of successful pre-college engineering programs.

IV. Other Initiatives Include:

A. Establishing an engineering education roundtable with industry, professional society, and private foundation participation

B. Convening a meeting of university presidents and provosts with high level industrial representation to articulate and discuss the transformed NSF vision of integrating education and research.

C. Involving a broader segment of engineering employers, including small industries and non-traditional employers, in partnerships with academe, government entities, NAE, professional societies and ABET to provide input and intellectual resources to engineering education reform.

D. Forming regional partnerships to coordinate and evaluate K-14 outreach programs, under the leadership of engineering deans working with their own industry boards and professional educators

Appendix C:

Background Materials

Systematic Engineering Education Reform: An Action Agenda

Why Are We Here?

This workshop is about getting on with it—"it" being the matter we have all heard, talked, and read about so much in recent years—workable, systemic, long-term change in the way undergraduate engineering education is carried out. You are here because you represent industry, academe, government, professional societies, and accreditors and because you are innovators, enablers, implementors, and committed national team members whose insights and shared experiences can come together in a plan for action to guide future NSF investment.

What Does NSF Want and Why?

NSF's prime focus is to enable the nation's capacity to perform through a holistic investment in fundamental research and education. The Foundation has demonstrated its willingness to support ventures in areas that are riskier than those that universities or industry are willing to underwrite alone. The Engineering Education Coalitions are good examples, as are the Engineering Research Centers. The Coalitions began as experimental ventures, each committed to its own, self-selected approach to the achievement of common goals—curriculum innovation, creative new approaches to the delivery of undergraduate engineering education; a substantial increase in the number of engineering degrees awarded to members of underrepresented groups—all focused on creating an integrative undergraduate engineering experience. There are now eight Coalitions involving 60 institutions. All engage in outreach to high schools and two-year colleges.

Undergraduate curricula reside in the educational spectrum between high school and graduate studies or a career coupled with lifelong learning; in some cases, a portion of the curriculum is delivered through a two-year college. A successful vision for systemic reform demands a clear view of this spectrum and of the continuity required to implement an action agenda for the entire undergraduate experience.

The Coalitions, together with other educational innovations sponsored by NSF in recent years, have already produced valuable information about some approaches that work. Examples are integration of design concepts into the curriculum at all levels; horizontal integration across engineering, the basic sciences, mathematics, and humanities; and a sea change in faculty perspective, away from the traditional delivery of information and toward the development of students as emerging engineering professionals and life-long learners. Some approaches tried by various Coalitions have not worked and have been changed or abandoned. NSF understands risk and does not expect that all experiments will succeed. On the other hand, NSF will not support continuation of unsatisfactory approaches just because they have been created.

What Will NSF Do With the Results of Our Effort?

Lasting, systemic change requires that successful innovations be institutionalized so that faculty come to view them as the norm, a task substantially more difficult than developing the innovations themselves. The Engineering Directorate leadership is asking for your best advice in defining how this task should be accomplished, what should be done next, who should be the agents of change for implementing the various steps of the action agenda, and how NSF leadership and investment can best be directed to support this agenda.

Engineering Education for the 21st Century: Why, What, How?

Why Change Now? Challenges to 21st Century Engineers

- Intelligent technology offers greater creative opportunity; ability to work smarter;
- Global workplace demands multi-cultural skills; expanding social infrastructure needs talent for complexity;
- Massively-integrated populations place environment, health, and safety at the front end of design;
- Eclectic, constantly changing work environment calls for astute interpersonal skills;
- Changing demographics; success in serving a diverse customer base requires a diverse workforce.

A Change to What? Characteristics of 21st Century Engineering Education

Broad structural and cultural, rather than incremental, changes in undergraduate engineering education are required. As the focus for this change, graduates must be educated to:

- Understand the functional core of the engineering process;
- Analyze and synthesize; formulate problems and solve them; become adept at group problem-solving strategies;
- Think across disciplines (lateral thinking) as well as in disciplinary depth (vertical thinking);
- Communicate ideas effectively to diverse groups, including non-engineers; act both independently and as a team member;
- Recognize, contribute to, and enjoy the relationship of the engineering enterprise to the social/economic/political context in which they live and work;
- Develop the motivation, knowledge base, and intellectual capability for career-long learning.

How to Change? Characteristics of 21st Century Education

To achieve these results, engineering education must:

- Place primary emphasis on the development of students as emerging professionals;
- Make the study of engineering attractive, exciting, and fulfilling throughout; seriously engage students in engineering from the day they matriculate;
- Make active learning the predominant engineering student learning mode;
- Draw engineering faculty to a dedicated investment in the teaching of undergraduates;
- Increase the diversity of student academic backgrounds and the numbers of women and underrepresented minorities who succeed in engineering study;
- Give students an appreciation for the realities of engineering practice through regular, well-planned interaction with industry.

The Action Agenda: Challenges and Questions

The Action Agenda must respond to the challenges and questions implicit in realizing the new paradigm for engineering education in the 21st Century. These challenges include:

Changing the Culture on Campus for Engineering Education

We must change the usual engineering school academic culture. *How can we*

- Redefine faculty roles to support the new paradigm?
- Realize a faculty reward and recognition system that supports the redefined roles?
- Encourage faculty to invest their efforts in engineering education?
- Enable students to *work smarter* and be more involved in their education?

- Infuse CQI concepts into both educational process and content?
- Adapt college, department, and other institutional structures to encourage the changes needed?

Resources: Human, Financial, and Other

Engineering education today is highly resource-intensive, requiring significant investments in faculty, support staff, and facilities. Hence, innovative use of resources and maximum leveraging of multiple sources of support will be critical to successful implementation and institutionalization of the new paradigm. *How can we:*

- Leverage multiple sources of support to provide the resources needed for 21st Century engineering education?
- Form effective, resource-sharing partnerships among engineering schools?
- Structure engineering school partnerships with industry to offer appropriate incentives to both parties?
- Structure future NSF investment most effectively to stimulate and encourage broad-based change in engineering education?

Maintaining the Change

Beyond realizing the engineering education paradigm for the 21st Century, we must sustain the change so that the new paradigm becomes the norm. *How can we:*

- Help institutions maintain the changes they make to realize the new paradigm?
- Sustain, on a long term basis, enhanced student exposure to the world of engineering practice?
- Support ABET efforts to encourage and sustain the new paradigm?

Appendix D:

Workshop Schedule

Systemic Engineering Education Reform: An Action Agenda

A Workshop Sponsored by the National Science Foundation Engineering Directorate Arlington Renaissance Hotel, Arlington, VA, July 11-13, 1995

Schedule

Day I: Tuesday, July 11

1:00 pm	Introduction	Ernst Peden
1:10 pm	Perspective: How We Got Here	Willenbrock
1:30 pm	Perspective: Engineering Employer Needs	McMasters
2:00 pm	Perspective: Engineering Education for 2020 and Beyond	Agogino
2:30 pm	The Players for Transforming Engineering Education: Potential Roles	Phillips
3:00 pm	Break	
3:30 pm	The NSF Engineering Education Coalitions Program: Lessons Learned and Potential for Change	Prados
4:00 pm	What Is an Action Plan? Issues To Be Addressed	Peden Ernst
4:30 pm	Challenge to Action	Bordogna
5:00 pm	Adjourn for Day I	
Evening	Workshop and Small Group Leaders Meet to Resolve Any Remaining Questions on Small Group Operation	

Day II: Wednesday, July 12

8:30 am	Instructions to Teams	Ernst Peden
8:40 am	Brainstorm; Evaluate Options	Individual Teams
10:00 am	Break	
10:30 am	Converge to Preliminary Recommendations	Individual Teams
12:00 noon	Lunch; Recorders Prepare Recommendation Summaries	
1:30 pm	Share Recommendation Summaries Among Teams; Questions for Clarification Only	Peden Ernst
2:00 pm	Evaluate Preliminary Recommendations	Reconstituted Teams
3:00 pm	Break	
3:30 pm	Converge to Revised Recommendations	Reconstituted Teams

5:00 pm	Adjourn for Day II
Evening	Workshop and Small Group Leaders Meet to Adjust Day III Strategy, As Needed

Day III: Thursday, July 13, 1995

8:00 am	All Participants Meet in Plenary Session to Develop Draft Action Plan; Recorders Share Revised Recommendations; Participants Discuss and Prioritize Recommendations, To Include: • What Needs To Be Done • Commitment to Follow-Up Action by Specific Groups • Guidance for NSF Leadership and Investment
9:30 am	Break
10:00 am	Continue Plenary Discussion
12:00 noon	Workshop Adjourns

Appendix E:

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